April 1954 E-875

United States Department of Agriculture
Agricultural Research Service
Entomology Research Branch

EVALUATION OF DUSTS AND SPRAYS FOR THE PROTECTION OF SHELLED CORN FROM INSECT ATTACK[1/]

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In recent years the demand for adequate supplies of insect-free grain for milling purposes has caused the emphasis to be placed on prevention rather than control of insect pests. Protective dusts and sprays provide promising means of protection. Dusts containing pyrethrins synergized with piperonyl butoxide are on the market.

In the fall of 1952 an experiment was undertaken at Beattie, Kans., to determine whether these dusts and sprays would protect shelled corn from insect attack for long storage periods in farm-type bins. This was a cooperative study by the Commodity Research Division of the Grain Branch of the Production and Marketing Administration (now the Grains and Feeds Section, Market Organization and Costs Branch, Agricultural Marketing Service), acting for the Commodity Credit Corporation, and the Division of Stored-Product Insect Investigations of the Bureau of Entomology and Plant Quarantine (now the Stored-Product Insects Section, Biological Sciences Branch, Agricultural Marketing Service).

Materials

The corn used in this work was grown in 1949, and had been shelled and stored at Beattie since the fall of 1950. The bins were of frame construction, 24 by 16 feet and 10 feet high at the eaves, with a capacity of 3,000 bushels.

The corn was infested with several species of grain beetles, the saw-toothed grain beetle (Oryzaephilus surinamensis (L.)) being predominant. No weevil infestation was found.

Nine formulations containing pyrethrins, ryania, or lindane were applied to the shelled corn as indicated in table 1.

1/ Part of a dissertation presented in partial fulfillment of the requirements for the degree of doctor of philosophy in entomology at Kansas State College.

Table 1.--Spray and dust formulations applied to bins of shelled corn.

Formulation		Application rate per 1,000 bushels	Bins treated	Insecticide applied
	Percent	Gallons	Number	P.p.m.
Sprays				
1. Pyrethrins-piperonyl butoxide concentrate (5-50)	5	2	3	1.04
Carbon tetrachloride	93			
Inert ingredients	2			
2. Pyrethrins-piperonyl butoxide concentrate (1-10)	1.18	8	3	1.23
Water and emulsifier	98.9			
Dusts		**Pounds**		
3. Pyrethrins	0.05	100	3	0.89
Piperonyl butoxide	.80			
Talc	99.15			
4. Pyrethrins	0.08	100	2	1.43
Sulfoxide	1.10			
Ground rice hulls	98.82			
5. Pyrethrins	0.08	75	1	1.07
Piperonyl butoxide	1.10	100	1	1.43
Corn-cob flour	98.82			
6. Ryania (ground stems)	100	45	2	804
		60	2	1071
7. Ryania (ground stems)	95.8	45	2	770
Sulfoxide	3.2	60	3	1026
Inert material	1.0			
8. Ryania (ground stems)	95.8	45	2	770
n-Propyl isome	3.2	60	3	1026
Inert material	1.0			
9. Lindane	1.0	45	1	8.1
Wheat flour	99.0	60	1	10.7

Procedure

Twenty-five binfuls of shelled corn were transferred into empty bins, and dusts or sprays were applied to the corn during the process. Augers were used to transfer the corn. One auger removed the corn from a bin and dropped it into the hopper of a second auger, which elevated it into an empty bin (fig. 1). The rate of movement was approximately 500 bushels an hour; thus about 6 hours were required to turn each bin.

The sprays were applied in a fan-shaped pattern onto the grain stream as it dropped from the first auger into the hopper of the second auger (fig. 2). Formulation No. 1 was applied by means of a pneumatically operated applicator tank equipped with a flowmeter which was set to deliver 2 gallons per 1,000 bushels. Formulation No. 2 was applied by use of a gear pump set to deliver 8 gallons per 1,000 bushels.

The dusts were applied to the grain stream, as it was elevated into the second bin, by means of an applicator, which was attached to the auger near its lower end (fig. 3). The applicator had internal rotating agitator blades to prevent the dust from bridging and to insure an even flow into the auger. The screw conveyor in the auger tube mixed the dust with the shelled corn while elevating the corn to the bin, and further mixing occurred as the corn fell into the bin. To prevent undue loss of dust, the upper end of the auger and the filling hatch of the bin were covered with a tarpaulin. After the bins were filled with the dust-treated corn, a capping of dust, about 10 pounds per bin, was applied by running dust alone through the auger. The corn was then leveled and raked to distribute the dust uniformly throughout the top 6 inches. Three bins were left untreated as checks.

The treated bins were sampled at monthly intervals until December 1953, except for some that were inadvertently fumigated in September. Samples were drawn with a 5-foot grain trier from six locations in each bin--the top and bottom 5 feet, at the center and about 3 feet from each end wall. The samples were sifted and the living insects were counted. The mean number of insects per 1,000 grams of shelled corn was then computed.

The three bins treated with formulation No. 2, which contained water, were also sampled before treatment and 1 week and 3 weeks after treatment, and the moisture content was determined with a Steinlite moisture meter.

The samples taken after 2, 4, 7, 9, and 11 months were tested in the laboratory to ascertain whether or not enough deposit was present to cause insect mortality. Each of the first four samples was infested with 25 adult confused flour beetles (Tribolium confusum Duv.), and the 11-month sample was infested with 25 adult rice weevils (Sitophilus oryza (L.)). Mortality counts were made after 1 and 3 weeks of exposure.

The two bins treated with formulation No. 9, containing lindane, were sampled and analyzed chemically after 3 months. One bin treated with each formulation containing ryania (Nos. 6, 7, and 8) was sampled and the residue determined by bioassay. The bioassays were made by courtesy of S. B. Penick & Company.

Samples of shelled corn from each treated bin were forwarded to the Chicago Board of Grain Supervisors for an opinion as to the effect of treatments on the grade.

Results

The numbers of insects found in the treated bins at the various sampling periods are given in table 2. In all bins the populations showed a pattern usually followed in stored grain in Kansas--that is, a decline from October to December as the temperature drops and a low level until the temperature of the grain mass begins to rise in the late spring or early summer, this buildup becoming evident in July and reaching a peak in September or October. Should the concentration of insects be sufficient to cause heating, the population may increase instead of decreasing during the winter months.

The synergized pyrethrins dust in a talc base (No. 3) gave complete protection during the entire period from September 1952 to October 1953, except for an infestation, which was believed to be due to a roof leak and a consequent high-moisture area, in the last month in one bin. The increased performance over synergized pyrethrins in an organic base (No. 5) is considered to be due to the use of talc, which is known to give some protection against stored-grain insects. However, this formulation caused the corn to be graded DLQ (distinctly low quality) and therefore would not appear to be acceptable for use on shelled corn that will enter market channels.

The bin treated with ryania-n-propylisome (No. 8) at 60 pounds per 1,000 bushels and one of two treated at 45 pounds also gave complete protection for the entire period.

The bins treated with ryania alone (No. 6) and ryania-sulfoxide (No. 7) at both rates and one bin treated with lindane (No. 9) at 60 pounds had the next lowest insect populations and gave almost complete protection.

The bins treated with synergized pyrethrins in organic diluents (Nos. 4 and 5) at 100 pounds per 1,000 bushels held the insect population down to a relatively low level.

Of the two sprays, synergized pyrethrins in a water base (No. 2) gave the better protection, being about equal to that given by dusts Nos. 4 and 5. The spray containing carbon tetrachloride (No. 1) gave only partial control in the critical August-September period.

The moisture content of the corn treated with synergized pyrethrins in a water base (No. 2) decreased rather than increased after the treatment as shown in table 3.

Table 2.--Insect populations found in samples from bins of shelled corn treated with insecticide dusts and sprays in the fall of 1952, Beattie, Kans.

Formulation	Dosage per 1,000 bushels	Number of insects per 1,000 grams of shelled corn															
		1952 Sept.	Oct.	Nov.	Dec.	1953 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Gallons																
1. Pyrethrins-piperonyl butoxide-carbon tetrachloride	2	16.0[1]	0.7	0.7	0	0.7	0	2.0	0	0	2.6	1.3	73.3	36.0[2]	-	-	-
		14.6	2.0	0	0	0	0	0	0	0.7	0	0.7	15.3	35.3	42.6	-	-
		7.3	1.3	0	0.7	0	0	0	0	0	0.7	0.7	19,3	15.3	-	-	-
2. Pyrethrins-piperonyl butoxide-water	8	2.6	0	0	0	0	0	0.7	0	0	1.4	0	12.6	4.0[2]	-	-	-
		42.0	0	0	0	0	0	0	0	0	0	0	0	2.6	3.3	0	0.7
		24.0	1.3	0.7	0	0	0	1.3	0	0	0.7	0	0.7	2.0	1.3	0.7	1.3
	Pounds																
3. Pyrethrins-piperonyl butoxide-talc	100	3.3	0	0	-	0	0	0	0	0	0	0	0	0	60.0[3]	-	-
		22.0	0	0.7	-	0	0	0	0	0	0	0	0	0	0	-	-
		66.6	0	0	-	0	0	0	0	0	0	0	0	0[2]	-	-	-
4. Pyrethrins-sulfoxide-ground rice hulls	100	-	19.3	0	-	0	0	0	1.3	0	0	0	1.3	3.0	2.0	2.6	1.3
		-	27.3	0	-	0	0	0	0	0	0.7	23.3	0	3.3[2]	-	-	-
5. Pyrethrins-piperonyl butoxide-corn cob flour	75	-	-	16.6	0.7	0	0	0	0	0	0.7	8.0	64.0	4.6[2]	-	-	-
	100	-	-	22.0	0	0	0	0	0	0	0.7	0	6.6	8.0	2.0	0	0
6. Ryania	45	106.6	7.4	4.6	-	6.0	1.3	4.6	0	0	0	0	0.7	0.3[2]	-	-	-
		33.3	2.0	1.3	-	0	0	0	1.3	0	0.7	0	0	0.7	0	0	0
	60	19.3	2.6	0.7	-	0.7	0	0.7	0	0	0.7	0	0.7	0	0	0	0
		30.6	4.0	2.0	-	0	0.7	0	0	0	0	0	1.3	0	0	0.7	0
7. Ryania-sulfoxide	45	-	4.3	5.3	-	0.7	-	0.7	0	0	0	0	0	0.7	0	0	-
		-	148.0	0	-	0	-	0	0	0	0	0.7	0.7	1.3	2.6	0	-
	60	-	107.3	0	-	0	-	0	0	0	0	0	0.7	0	0	-	-
8. Ryania-n-propyl isome	45	-	30.6	0	-	0	-	0	0	0	0	0	0	0	0	0	0
		-	4.6	0	-	0	-	0	0	0	0	0	0	0.7	0	0	0
	60	-	3.3	0	0	-	0	0	0	0	0	0	0	0	0	-	-
9. Lindane-flour	45	-	-	16.0	-	0	0	0	0	0	2.0	8.0	52.6	1.3[2]	-	-	-
	60	-	-	1.3	-	0	0	0	0	0	0	0	1.3	0	1.3	-	-
Check		24.0	24.0	25.3	2.6	6.0	15.3	4.6	6.0	3.3	5.3	18.0	126.7	108.0	20.0[2]	-	-
		6.0	6.0	8.0	9.3	10.0	0	2.7	2.7	2.7	0	0.7	5.3	40.0	7.3[2]	-	-
		4.6	4.6	2.6	2.6	6.7	1.3	2.7	0	2.7	0.7	0.7	6.0	60.0	1.3[2]	-	-

1/ The first figure recorded for each bin represents the number of insects per 1,000 grams of shelled corn just prior to treatment.
2/ Bin fumigated the middle of September 1953; September samples taken after fumigation.
3/ This infestation attributed to a wet area beneath a leaky portion of the roof.

Table 4.--Mortality of test insects confined in corn treated with various dusts and sprays. 25 insects in each test.

Formulation	Rate of application per 1,000 bushels	Months after treatment	Percent mortality after indicated period			
			Confused flour beetle		Rice weevil	
			1 week	3 weeks	1 week	3 weeks
	Gallons					
1. Pyrethrins-piperonyl butoxide-carbon tetrachloride	2	2	3	40	-	-
		4	-	42	-	-
		7	1	42	-	-
		9	11	19	-	-
		11	-	-	11	11*
2. Pyrethrins-piperonyl butoxide-water	8.3	2	2	2	-	-
		4	-	26	-	-
		7	1	82	-	-
		9	2	9	-	-
		11	-	-	46	46*
	7.5	2	16	-	-	-
		4	-	4	-	-
		7	3	7	-	-
		9	21	31	-	-
		11	-	-	0	0*
	Pounds					
3. Pyrethrins-piperonyl butoxide-talc	100	2	36	65	-	-
		4	-	23	-	-
		7	0	57	-	-
		9	6	26	-	-
		11	-	-	40	40
4. Pyrethrins-sulfoxide-ground rice hulls	100	2	-	38	-	-
		4	-	51	-	-
		7	3	18	-	-
		9	15	16	-	-
		11	-	-	38	42

Table 4.--Continued

Formulation	Rate of application per 1,000 bushels	Months after treatment	Percent mortality after indicated period			
			Confused flour beetle		Rice weevil	
			1 week	3 weeks	1 week	3 weeks
	Pounds					
5. Pyrethrins-piperonyl butoxide-corn cob flour	100	2	-	52	-	-
		4	-	41	-	-
		7	1	32	-	-
		9	18	36	-	-
		11	-	-	12	80
	75	2	8	-	-	-
		4	-	35	-	-
		7	6	31	-	-
		9	2	15	-	-
		11	-	-	8	8*
6. Ryania	60	2	-	62	-	-
		4	-	96	-	-
		7	11	99	-	-
		9	6	80	-	-
		11	-	-	70	96
	45	2	-	50	-	-
		4	-	85	-	-
		7	6	100	-	-
		9	21	76	-	-
		11	-	-	58	92
7. Ryania-sulfoxide	60	2	-	44	-	-
		4	-	77	-	-
		7	82	100	-	-
		9	19	84	-	-
		11	-	-	68	96
	45	2	-	46	-	-
		4	-	96	-	-
		7	11	75	-	-
		9	21	86	-	-
		11	-	-	70	70

Table 4.- Continued

Formulation	Rate of application per 1,000 bushels	Months after treatment	Percent mortality after indicated period			
			Confused flour beetle		Rice weevil	
			1 week	3 weeks	1 week	3 weeks
	Pounds					
8. Ryania-n-propyl isome	60	2	-	64	-	-
		4	-	99	-	-
		7	36	100	-	-
		9	32	100	-	-
		11	-	-	100	100
	45	2	-	62	-	-
		4	-	97	-	-
		7	58	61	-	-
		9	8	98	-	-
		11	-	-	94	94
9. Lindane-flour	60	2	-	100	-	-
		4	-	99	-	-
		7	100	100	-	-
		9	4	100	-	-
		11	-	-	96	96
	45	2	-	44	-	-
		4	-	99	-	-
		7	5	2	-	-
		9	61	98	-	-
		11	-	-	0	0
Check		2	0.7	-	-	-
		4	-	11.0	-	-
		7	0.7	17.0	-	-
		9	6.0	6.0	-	-
		11	-	-	5	8*

*Samples showing evidence of reproduction after being held for 6 weeks at 80° F. and 70 percent relative humidity.

Summary

Various spray and dust formulations containing synergized pyrethrins, ryania, or lindane were applied to twenty-five 3,000-bushel bins of shelled corn at Beattie, Kans., in the fall of 1952, as the corn was transferred from one bin to another. Monthly samples from six points in each bin were taken through December 1953, and the insect populations were determined for each. No insects were found after treatment with a pyrethrins-piperonyl butoxide-talc dust at 100 pounds, or with ryania-n-propyl isome dust at 60 pounds per 1,000 bushels. The first formulation caused downgrading of the corn because of the inorganic base.

The insect population was held to a very low level by ryania, ryania-sulfoxide, and ryania-n-propyl isome dusts at 45 pounds or lindane-flour dusts at 60 pounds per 1,000 bushels. The ryania-sulfoxide formulation caused downgrading of the corn because of an objectionable odor.

Dusts of pyrethrins-sulfoxide-ground rice hulls and pyrethrins-piperonyl butoxide-corn cob flour at 100 pounds per 1,000 bushels and a spray containing pyrethrins-piperonyl butoxide-water applied at 10 gallons held insect populations to a relatively low level. A spray containing pyrethrins-piperonyl butoxide-carbon tetrachloride and dusts containing lindane-flour applied at 45 pounds and pyrethrins-piperonyl butoxide-corn cob flour at 75 pounds per 1,000 bushels failed to inhibit the development of dangerous insect populations.

Tests in which insects were confined for 3 weeks on samples of grain taken 2, 4, 7, 9, and 11 months after treatment gave results that correlated closely with the populations in the bins.

The moisture content of corn treated with the water-base spray decreased rather than increased in the 3 weeks following application.

Ryania residues remained high after 7 months but were rather variable. Lindane residues after 3 months were only one-thirtieth to one-fortieth of the amounts applied.

Figure 1.--Auger in position for transferring corn into an empty bin.

Figure 2.--Spray nozzle attached to grain delivery spout for applying sprays.

Figure 3.--Mechanical dust applicator attached to an auger.